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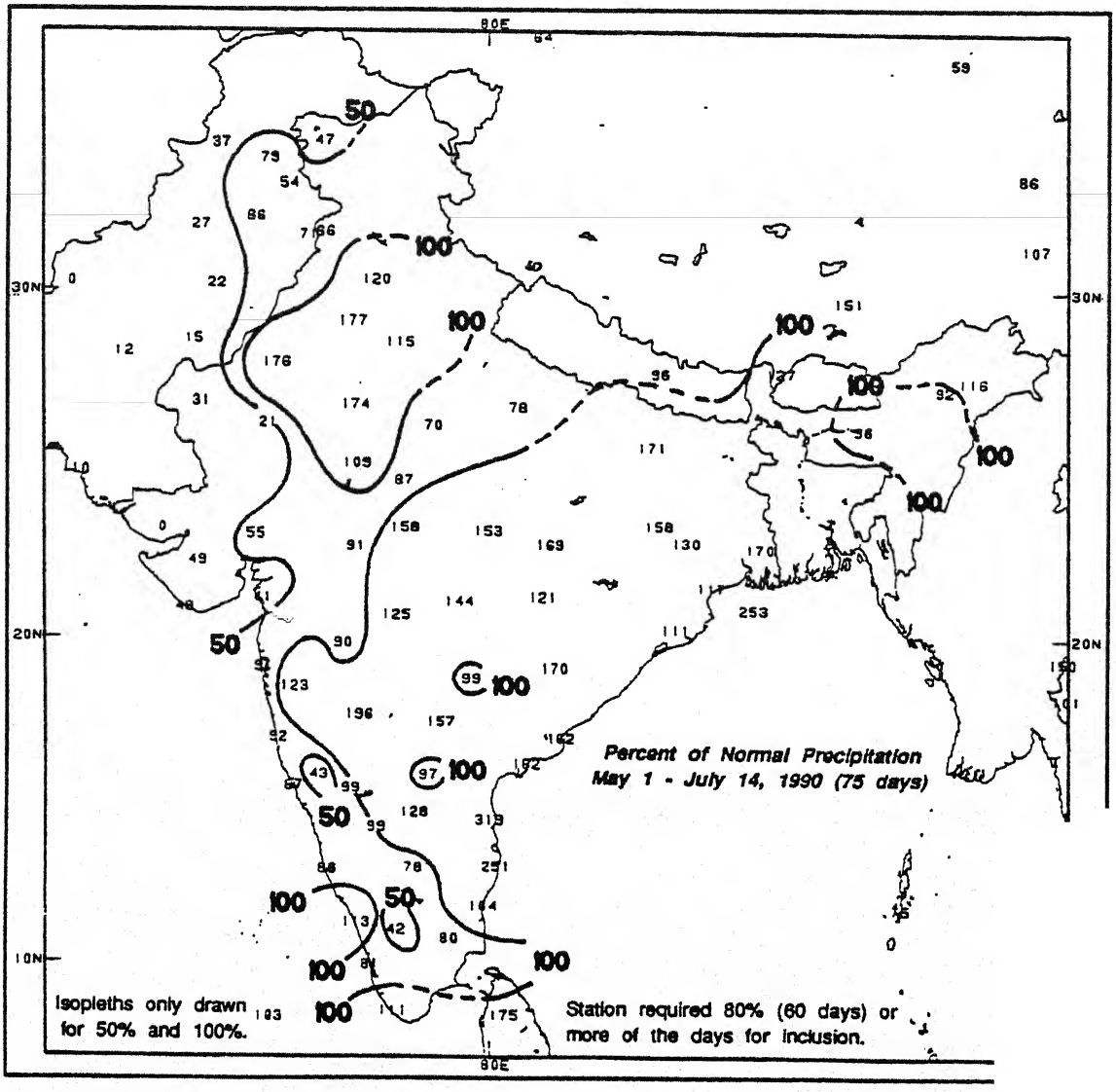
ADVISORY 90/6

CLIMATE ANALYSIS CENTER

CONTAINS:
REVIEWS OF
THE 1990 INDIAN
MONSOON AND
AFRICAN SAHEL
RAINY SEASON

WEEKLY CLIMATE BULLETIN

No. 90/28 **Washington, DC** **July 14, 1990**



THIS YEAR'S MONSOON SEASON ACROSS INDIA AND BANGLADESH HAS GENERALLY PROGRESSED NEAR OR SLIGHTLY AHEAD OF SCHEDULE, WITH SEASONAL RAINFALL MOSTLY AT OR ABOVE NORMAL. SO FAR, THE 1990 SEASON HAS INCLUDED: AN INTENSE TYPHOON THAT DEVASTATED THE SOUTHEASTERN INDIAN COAST IN EARLY MAY; SEVERE FLOODING IN SOUTHWESTERN INDIA AND NORTH

UNITED STATES DEPARTMENT OF COMMI
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTI
NATIONAL WEATHER SERVICE–NATIONAL METEOROLOGI
CLIMATE ANALYSIS CENTE

WEEKLY CLIMATE BULLETIN

This Bulletin is issued weekly by the Climate Analysis Center and is designed to indicate, in a brief concise format, current surface climatic conditions in the United States and around the world. The Bulletin contains:

- Highlights of major climatic events and anomalies.
- U.S. climatic conditions for the previous week.
- U.S. apparent temperatures (summer) or wind chill (winter).
- U.S. cooling degree days (summer) or heating degree days (winter).
- Global two–week temperature anomalies.
- Global four–week precipitation anomalies.
- Global monthly temperature and precipitation anomalies.
- Global three–month precipitation anomalies (once a month).
- Global twelve–month precipitation anomalies (every three months).
- Global three–month temperature anomalies for winter and summer seasons.
- Special climate summaries, explanations, etc. (as appropriate).

Most analyses contained in this Bulletin are based on preliminary, unchecked data received at the Climate Analysis Center via the Global Telecommunications System. Similar analyses based on final, checked data are likely to differ to some extent from those presented here.

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GLOBAL CLIMATE HIGHLIGHTS

MAJOR CLIMATIC EVENTS AND ANOMALIES AS OF JULY 14, 1990

1. Alaska and Northwestern Canada:

HEAT WAVE ENDS.

Temperatures returned to within 2°C of normal after two weeks of record-breaking heat. Extreme maxima did not exceed 24°C anywhere in the region last week, signaling an end to the brief but exceptional warm spell [Ended after 3 weeks].

2. High Plains:

LITTLE OR NO RELIEF FROM DRYNESS.

Dry conditions intensified across the southern half of the High Plains and northern half of the Rockies as most locations measured less than 20 mm of rain. Moderate rains, however, provided localized relief for isolated locations in west-central Texas and extreme western Nebraska, where up to 43 mm and 38 mm, respectively, were measured [7 weeks].

3. East-Central United States:

HEAVY RAINFALL REDEVELOPS.

After three weeks of drying out, inundating rainfall redeveloped across much of the region and extended eastward to the Atlantic Coast. Between 50 and 150 mm soaked portions of the middle Mississippi, Ohio, and Tennessee Valleys as well as much of the Corn Belt, the central and southern Appalachians, the mid-Atlantic, and isolated locations across the Southeast. Amounts of 150 mm to 235 mm deluged isolated locales in Ohio, western Pennsylvania, southwestern Virginia, and northern Georgia [26 weeks].

4. Southeastern U.S. and the Bahamas:

IMPROVEMENT CONTINUES IN FLORIDA, BUT RELIEF IS SCATTERED ELSEWHERE.

Up to 180 mm soaked portions of northern Florida, with most locations measuring 35 mm to 100 mm, engendering further recovery across the state. In fact, short-term wetness has developed in extreme southern Florida. Relief was less evident, however, in the Bahamas and through the rest of the Southeast. Although scattered heavy thunderstorms dumped nearly 100 mm on isolated parts of the south Atlantic Coast, most locations reported 25 mm to 50 mm, with several small areas near the coast receiving less than 25 mm. Drier weather affected the Bahamas with only isolated locations reporting 25 mm to 40 mm and little or no rain elsewhere [14 weeks].

5. East-central South America:

DRYNESS DEVELOPS THROUGHOUT REGION.

After Uruguay and adjacent Brazil, Argentina, and Paraguay experienced exceptionally wet weather during much of Summer (December -February), unusual dryness has developed during the typically drier winter months. Since early June, most locations have received only 15% to 50% of normal precipitation, and a few isolated areas have failed to measure 10 mm of rain [6 weeks].

6. Southern Scandinavia:

HEAVY RAINS SOAK PREVIOUSLY DRY REGION.

After a relatively dry Winter and Spring, and while much of Europe continues to experience below normal rainfall, relatively heavy rainfall has soaked Denmark and southern sections of Norway and Sweden. Most locations have recorded 150 mm to 350 mm since early June, or approximately 2 – 3 times normal [5 weeks].

7. Southeastern Europe:

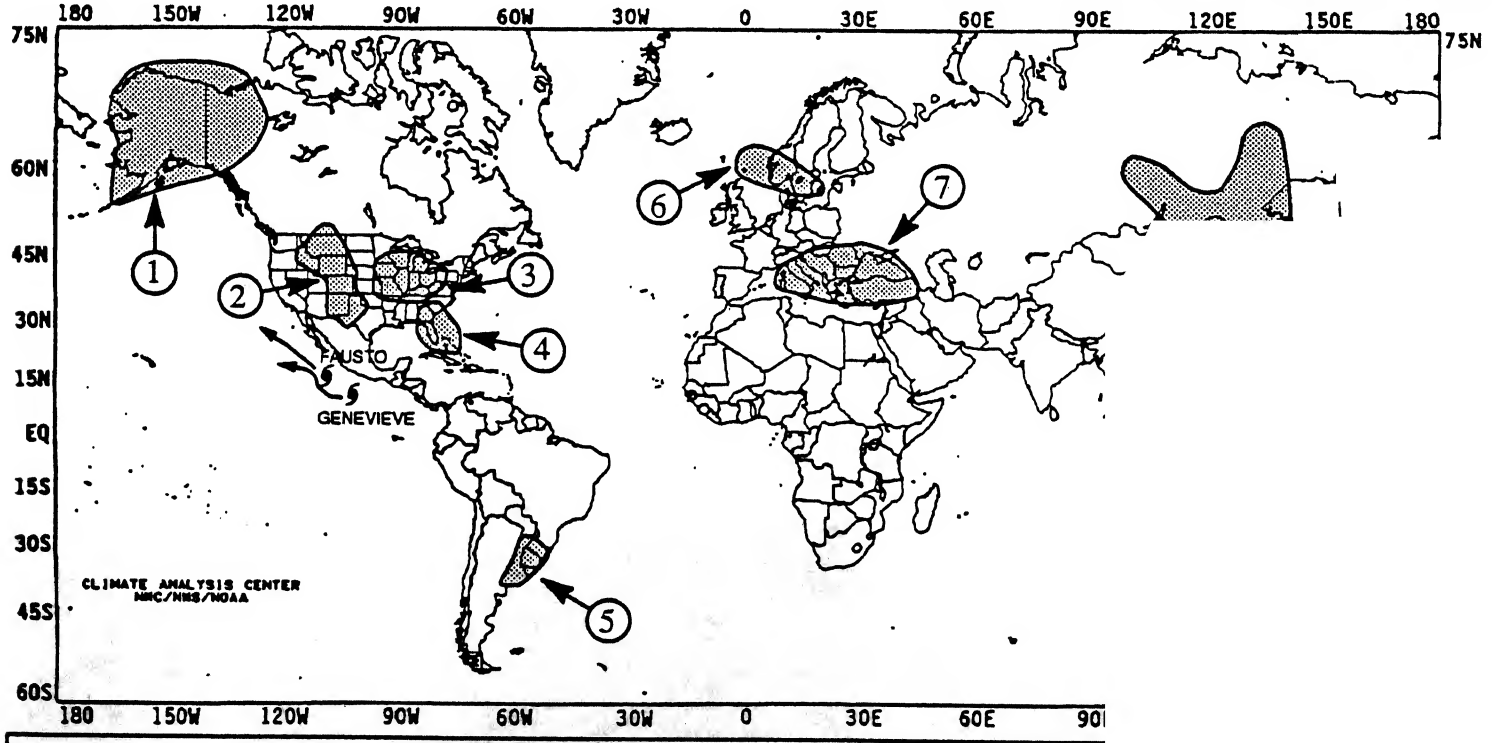
EXCEPTIONALLY DRY WEATHER CONTINUES.

Good rains (between 25 mm and 70 mm) soaked west-central and north-central Turkey while isolated locations across southeastern Greece, northern Romania, southern Yugoslavia and Bulgaria, and central and southern Italy recorded up to 45 mm. Elsewhere, little or no rainfall increased moisture deficits [11 weeks].

8. Eastern Asia:

SOUTHERN AREAS DRY OUT AS WETNESS SHIFTS NORTHWARD.

More typical rainfall totals settled in across Japan, Taiwan, the Philippines, and southeastern China. In fact, pockets of short-term dryness have developed along the eastern fringes of the afflicted region. Farther north and west, however, inundating rains continued, bringing portions of southeastern Siberia the worst floods of the century, according to press reports. Isolated locations across eastern Siberia, northeastern China, and the Koreas have measured more than three times the normal rainfall since early June, with weekly amounts ranging up to 335 mm across eastern Siberia. Korean totals generally ranged between 100 mm and 250 mm. In addition, much of south-central China remained unusually wet [16 weeks].



EXPLANATION

TEXT: Approximate duration of anomalies is in brackets. Precipitation amounts and temperature depa

MAP: Approximate locations of major anomalies and episodic events are shown. See other maps in tl temperature anomalies, four week precipitation anomalies, long-term anomalies, and other det

UNITED STATES WEEKLY CLIMATE HIGHLIGHTS

FOR THE WEEK OF JULY 8 – JULY 14, 1990

Wet weather returned to most of the eastern half of the nation after a brief two week hiatus. While numerous showers and thunderstorms provided some relief from dryness across the Tennessee Valley and the southern Atlantic Coast states, copious rains (up to 9.5 inches) produced flooding in parts of the southern and central Appalachians, mid–Atlantic, and eastern Ohio Valley (Figure 1). In the Far West, temperatures soared into the triple digits as far north as central Washington and southern British Columbia, but further south, welcome monsoonal rains dampened Arizona, Utah, New Mexico, and Colorado, diminishing both short–term dryness and wildfire threats. Meanwhile, unseasonably cool conditions prevailed in the nation's midsection as dozens of locations set record lows while several stations observed record low daily maximum temperatures (e.g. 63°F high at Indianapolis, IN on July 13). Farther north, widespread rains and lower temperatures aided firefighters in the Alaskan interior where wildfires have charred more than 537,000 acres during July alone.

During the first half of the week, a low pressure center and its trailing cold front located across the north–central U.S. slowly tracked eastward, triggering scattered showers and thunderstorms in the northern and central Plains, the Midwest, and New England. The cold front eventually stalled across the middle Mississippi and Ohio Valleys, the central Appalachians, and the mid–Atlantic, producing widespread convective activity and occasional severe weather in the those areas. Farther south, a trough of low pressure generated thundershowers across portions of the eastern Gulf and southern Atlantic Coasts. In areas missed by the thundershowers, temperatures climbed into the upper nineties and lower one hundreds. In the Far West, readings soared above 100°F at several interior Pacific Coast locations, but isolated thundershowers in parts of the Southwest and central High Plains produced some flash flooding and severe weather at a few locations.

The latter half of the week saw unseasonably hot weather continuing west of the Rockies, fall–like temperatures chilling the nation's midsection, and numerous thunderstorms pelting the eastern third of the country. A strong dome of high pressure moved out of Canada into the northern Plains, gradually nudging the western section of the stalled cold front southeastward into the western Gulf of Mexico, a rare July event. The eastern portion of the front, however, remained stationary across the eastern Ohio Valley, central Appalachians, and the mid–Atlantic. Weak waves of low pressure formed and moved along the front, producing additional showers and a few severe thunderstorms. On Saturday, strong thundershowers dumped 2 inches of rain in 2 1/2 hours on southern Nevada, closing some highways due to flooding and rockslides. By the week's end, another cold front pushed southeastward into the northern Rockies and Plains while the cold front in the East slowed its eastward progression, stalling along the Appalachians.

According to the River Forecast Centers, the greatest weekly totals (more than 5 inches) were observed in central Ohio and western Pennsylvania, the southern Appalachians, and portions of Virginia (Table 1). Elsewhere, heavy rains (more than 2 inches) fell along the western and southeastern Alaskan Coast, on much of the Ohio, Tennessee, and middle Mississippi Valleys, the Southeast, Appalachians, mid–Atlantic, and at isolated sections of the extreme southern Intermountain West and Rockies, central High Plains, and south–central Great Plains. Light to moderate precipitation occurred across the southern halves of the Intermountain West and Rockies and in much of the eastern two–thirds of the country. Little or no rain was observed along the West Coast, the northern halves of the Intermountain West and Rockies, and in portions of the central and southern Great Plains.

Hot weather returned to the desert Southwest and pushed northward to encompass the Pacific Northwest while last week's heat in the central U.S. shifted eastward into the southeastern quarter of the nation. Highs broke 100°F throughout the Intermountain West, setting many daily maximum temperature records during the week. A brief heat wave early in the week also produced triple–digit readings in the southern and central Great Plains, Tennessee Valley, and the southern Atlantic Coast. Temperatures averaged more than 7°F above normal in interior California, central Oregon and Washington, and western Nevada and Idaho (Table 2). Slightly warmer than usual conditions covered the western third of the country, and departures of +3°F to +6°F were common in the Carolinas, northern Georgia, and southern Virginia.

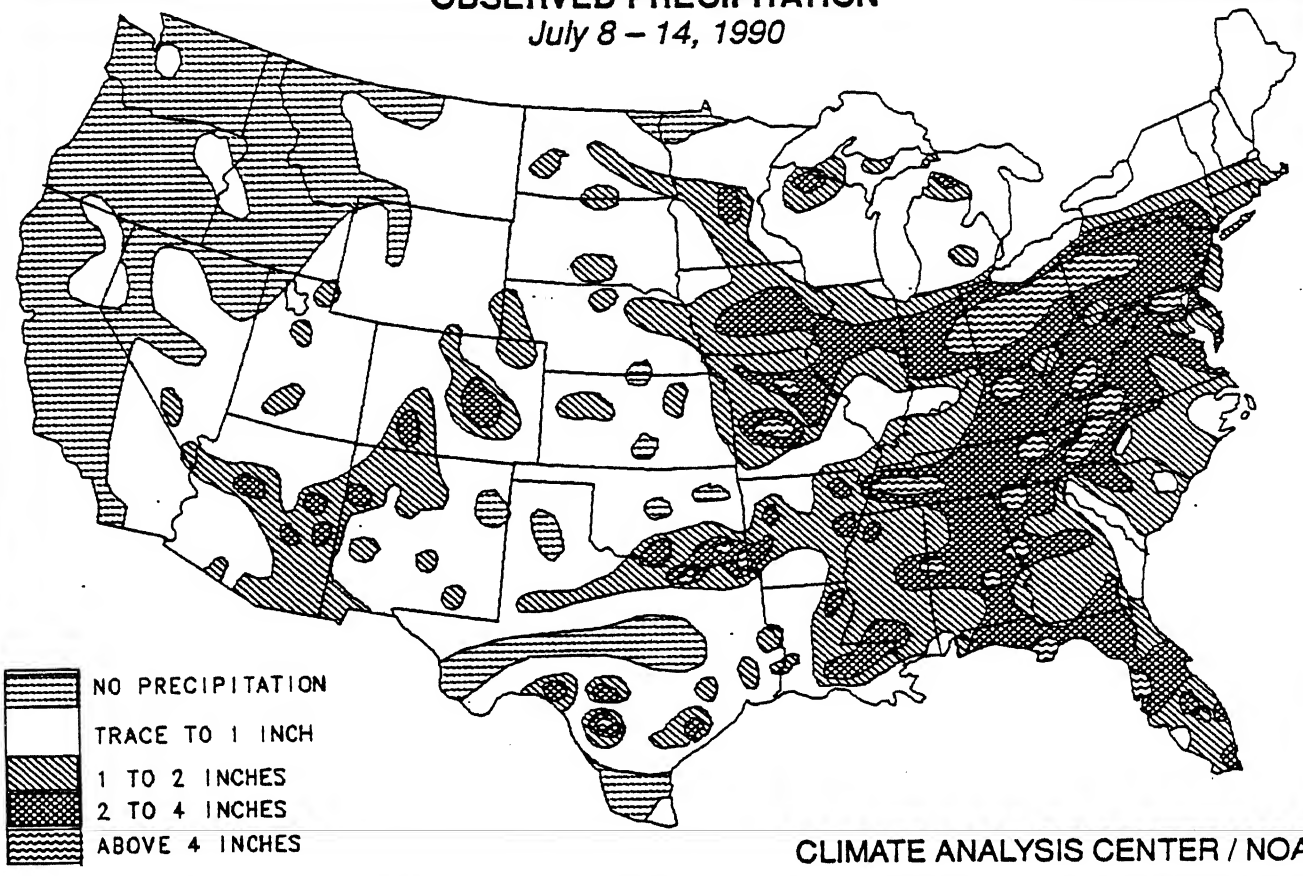
In sharp contrast, unseasonably cool air invaded the central and northeastern United States, especially later in the week, with dozens of stations in the nation's midsection reporting record lows. Combined with thick cloud cover and rain in the eastern U.S., many locations also observed record low maximum temperatures as highs remained in the sixties on July 12–13. The greatest negative departures (less than –6°F) occurred in the north–central Plains and western Corn Belt (Table 3).

TABLE 1. Selected stations with 4.00 or more inches of precipitation for the week.

STATION	TOTAL (INCHES)	STATION	TOTAL (INCHES)
MANSFIELD, OH	7.62	APALACHICOLA, FL	4.88
DAYTON, OH	6.91	COLUMBUS/LOCKBOURNE AFB, OH	4.78
VIRGINIA BEACH/OCEANA NAS, VA	6.78	TAMPA, FL	4.73
YAKUTAT, AK	6.58	ASHEVILLE, NC	4.71
KNOXVILLE, TN	6.24	BALTIMORE, MD	4.24
MONTGOMERY/MAXWELL AFB, AL	5.71	LEXINGTON, KY	4.23
COLUMBUS, OH	5.68	YOUNGSTOWN, OH	4.21
JACKSON, TN	5.54	ILIAMNA, AK	4.15
HICKORY, NC	5.20	DAYTON/WRIGHT-PATERSON AFB, OH	4.14
AKRON, OH	5.08		

OBSERVED PRECIPITATION

July 8 – 14, 1990



DEPARTURE OF AVERAGE TEMPERATURE FROM NORMAL (°F)

July 8 – 14, 1990

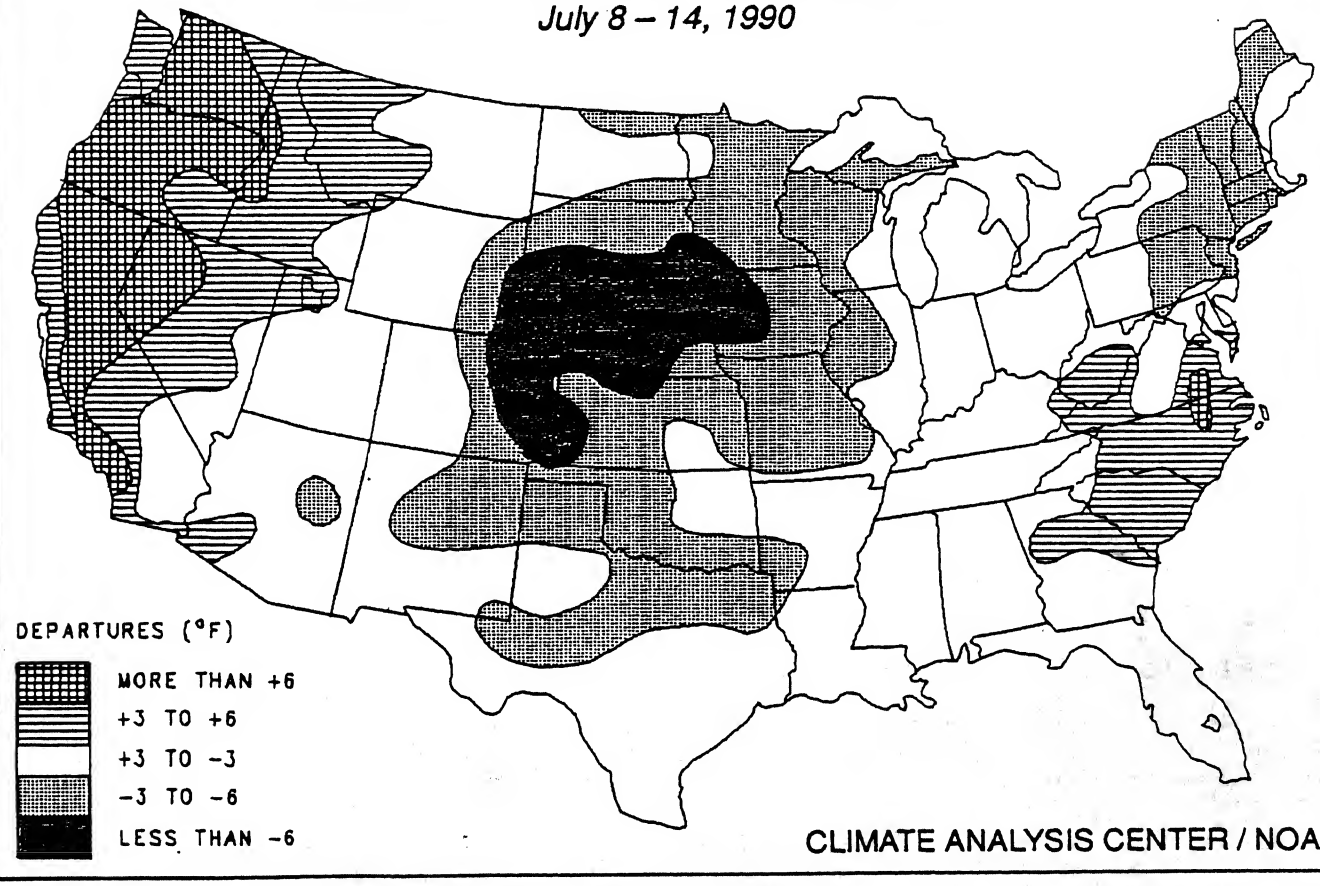


TABLE 2. Selected stations with temperatures averaging 6.0°F or more ABOVE normal for the week.

STATION	DEPARTURE (°F)	AVERAGE (°F)	STATION	DEPARTURE (°F)	AVERAGE (°F)
WALLA WALLA, WA	+10.2	85.1	WENATCHEE, WA	+7.5	81.0
MEDFORD, OR	+9.2	81.4	PORTLAND, OR	+7.5	74.8
REDMOND, OR	+8.8	74.6	RED BLUFF, CA	+7.4	89.5
LEWISTON, ID	+8.5	82.2	SEXTON SUMMIT, OR	+7.4	70.9
RENO, NV	+8.2	77.6	WINNEMUCCA, NV	+7.1	78.9
VICTORVILLE/GEORGE AFB, CA	+8.1	86.4	YAKIMA, WA	+7.1	77.3
SAN BERNADINO/NORTON AFB, CA	+7.9	84.4	SEATTLE-TACOMA, WA	+7.0	71.6
PENDLETON, OR	+7.9	81.4	FRESNO, CA	+6.6	87.5
SACRAMENTO, CA	+7.7	83.1	STOCKTON, CA	+6.6	84.0
SALEM, OR	+7.7	73.7	BELLINGHAM, WA	+6.1	66.0
EUGENE, OR	+7.6	74.3	FLORENCE, SC	+6.0	86.4

TABLE 3. Selected stations with temperatures averaging 6.0°F or more BELOW normal for the week.

STATION	DEPARTURE (°F)	AVERAGE (°F)	STATION	DEPARTURE (°F)	AVERAGE (°F)
GRAND ISLAND, NE	-8.6	67.9	SCOTTSBLUFF, NE	-6.7	67.3
NORTH OMAHA, NE	-8.3	69.3	SIOUX CITY, IA	-6.5	69.2
VALENTINE, NE	-8.0	66.4	RAPID CITY, SD	-6.2	66.2
OMAHA/EPPLEY, NE	-7.9	69.8	PUEBLO, CO	-6.2	70.6
AKRON, CO	-7.5	65.9	NORTH PLATTE, NE	-6.1	68.1
NORFOLK, NE	-7.4	68.3	DES MOINES, IA	-6.1	70.0
LA JUNTA, CO	-7.3	71.9	FORT COLLINS, CO	-6.0	65.4
CHEYENNE, WY	-6.9	61.4	DENVER, CO	-6.0	67.2
SIOUX FALLS, SD	-6.7	67.1			

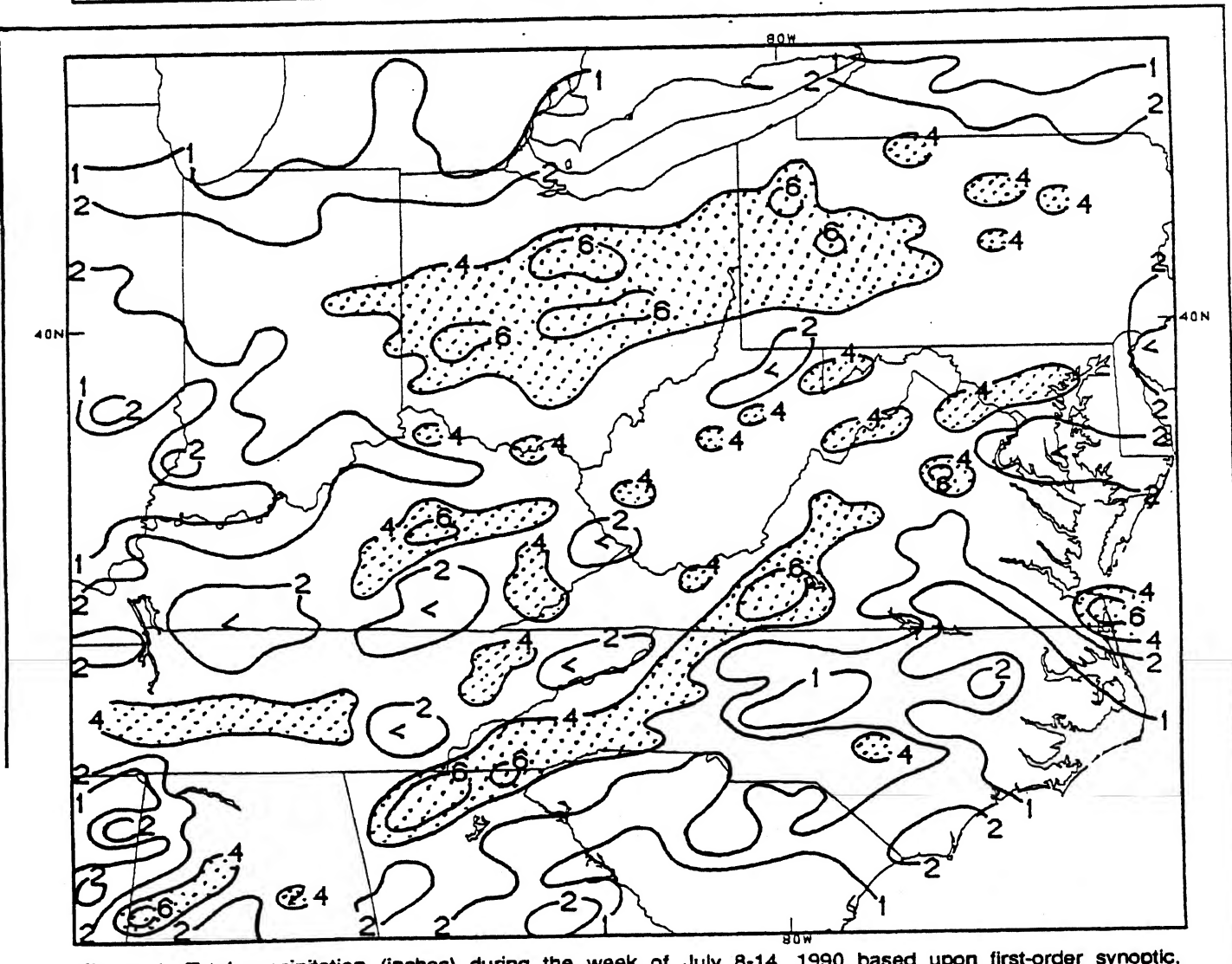
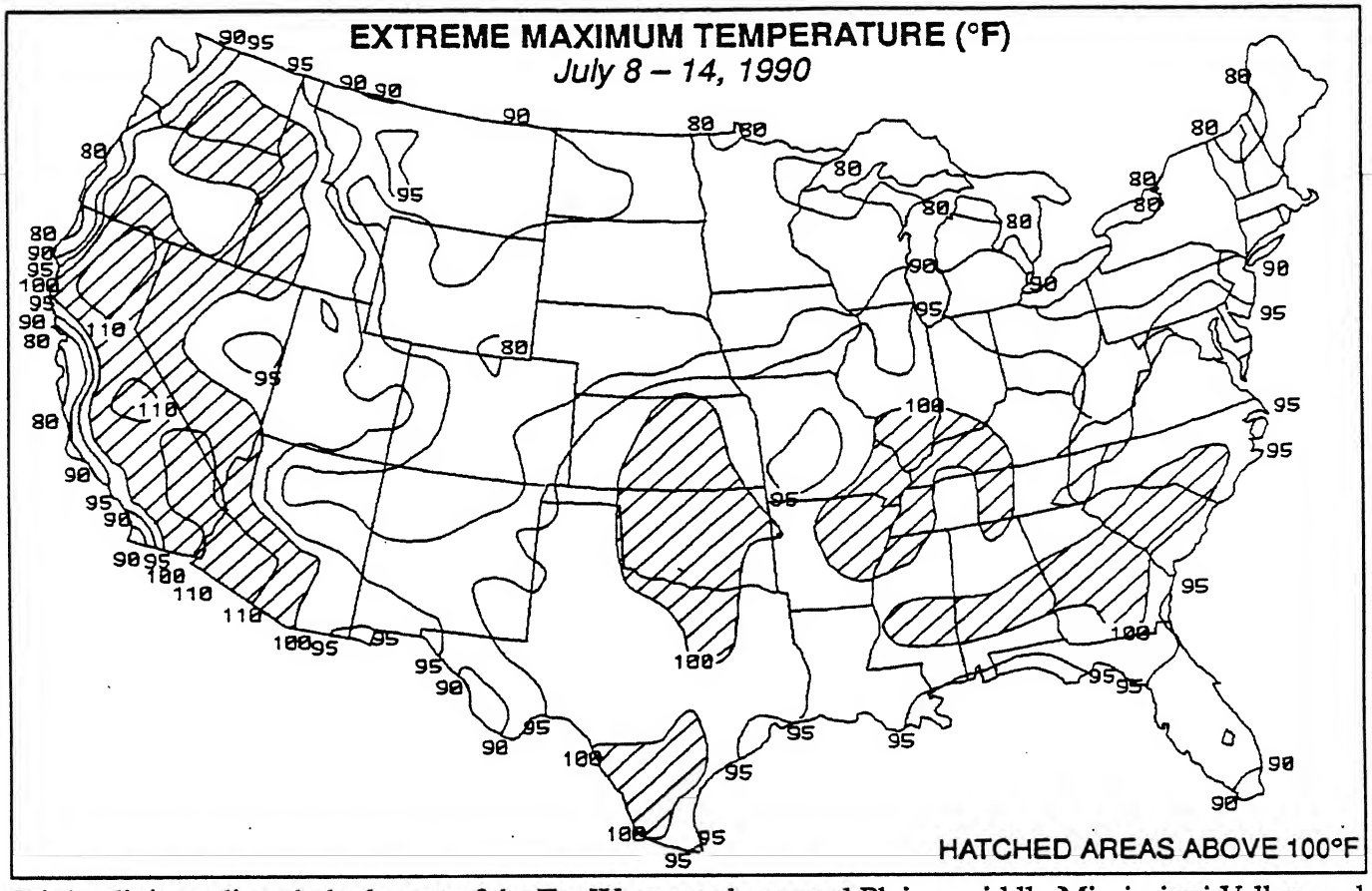
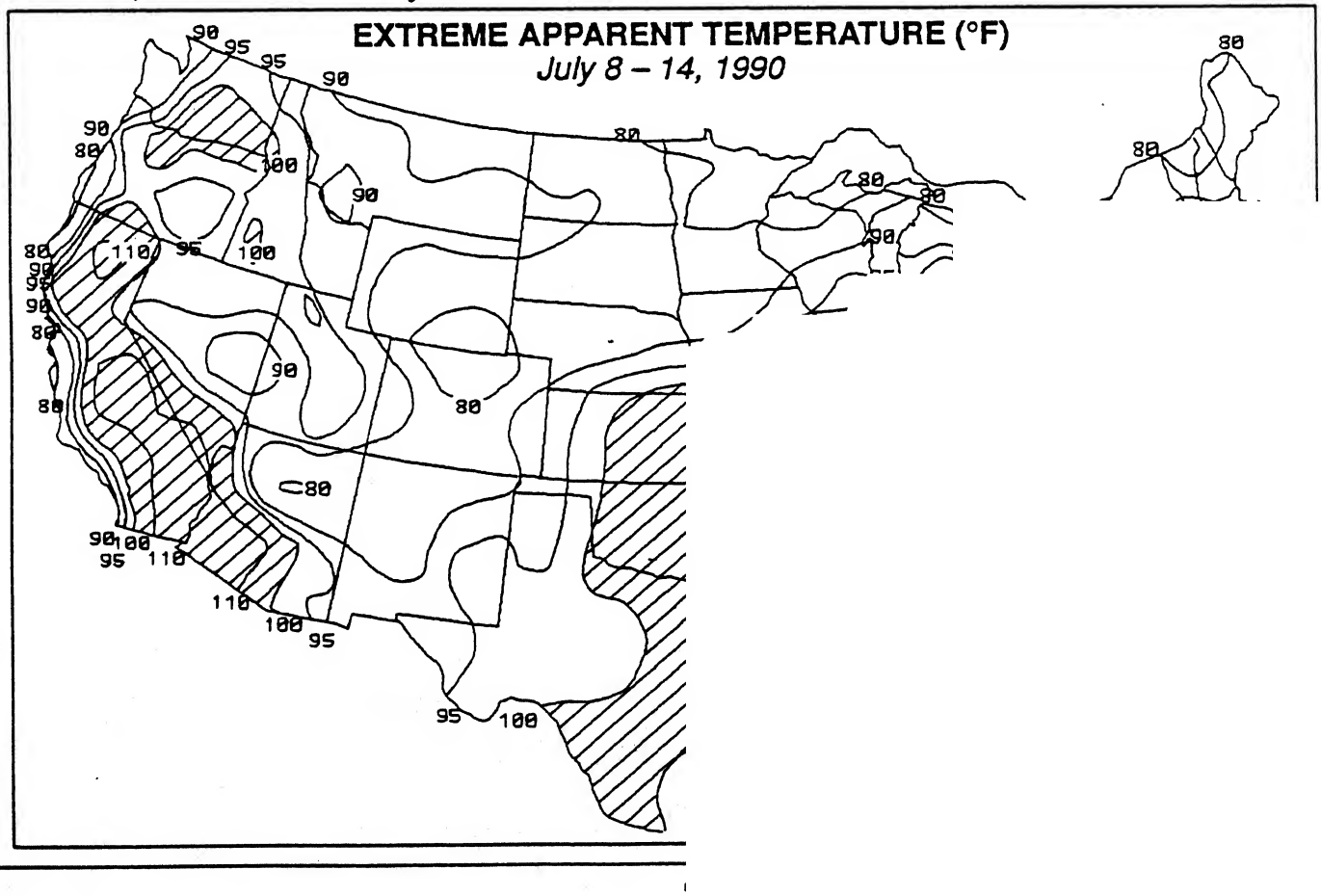
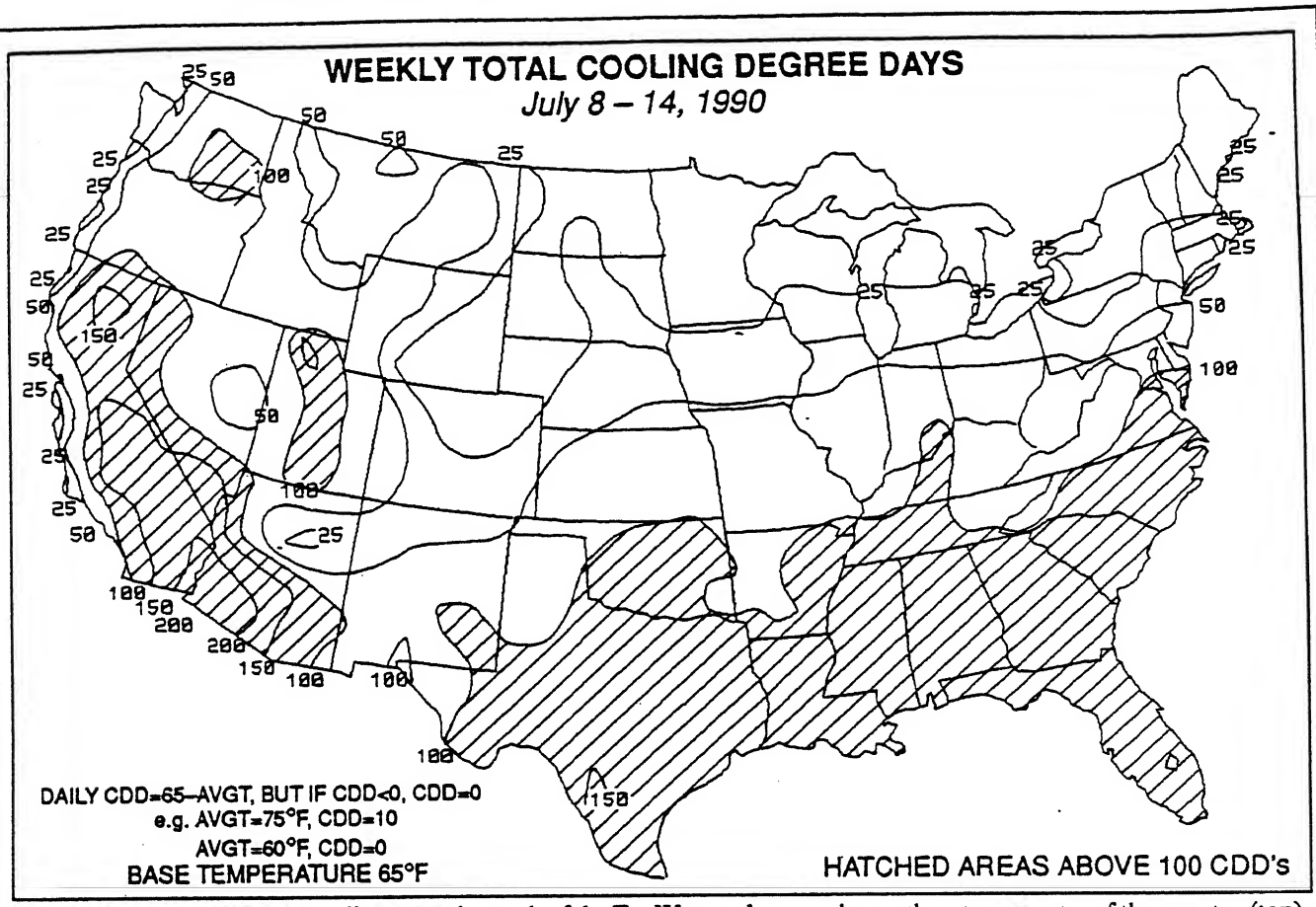


Figure 1. Total precipitation (inches) during the week of July 8-14, 1990 based upon first-order synoptic, airways, and the River Forecast Centers stations. Isohyets are only drawn for 1, 2, 4, and 6 inches, and stippled areas are more than 4 inches. After two relatively dry weeks, widespread showers and thunderstorms deluged much of the eastern half of the country, especially the Tennessee and eastern Ohio Valleys, the southern and central Appalachians, and parts of the mid-Atlantic. More than 8 inches of rain inundated portions of southwestern and southeastern Virginia while heavy rains in parts of central Ohio, western Pennsylvania, and northern Georgia caused some flooding.

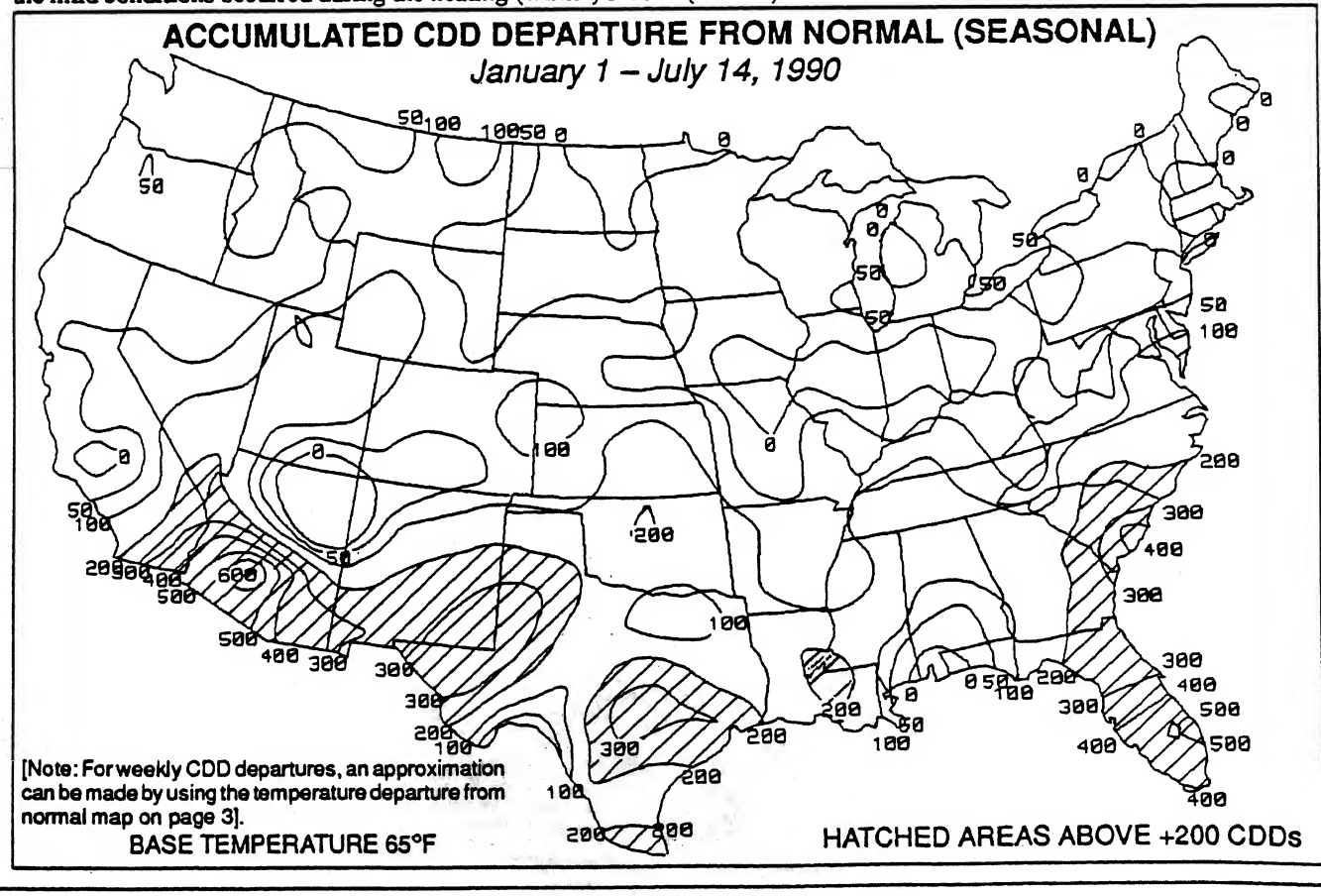


Triple–digit readings baked most of the Far West, south–central Plains, middle Mississippi Valley, and interior Southeast (top) while high humidities drove apparent temperatures above 100°F in the eastern Corn Belt, southern Ohio Valley, and mid–Atlantic (bottom).



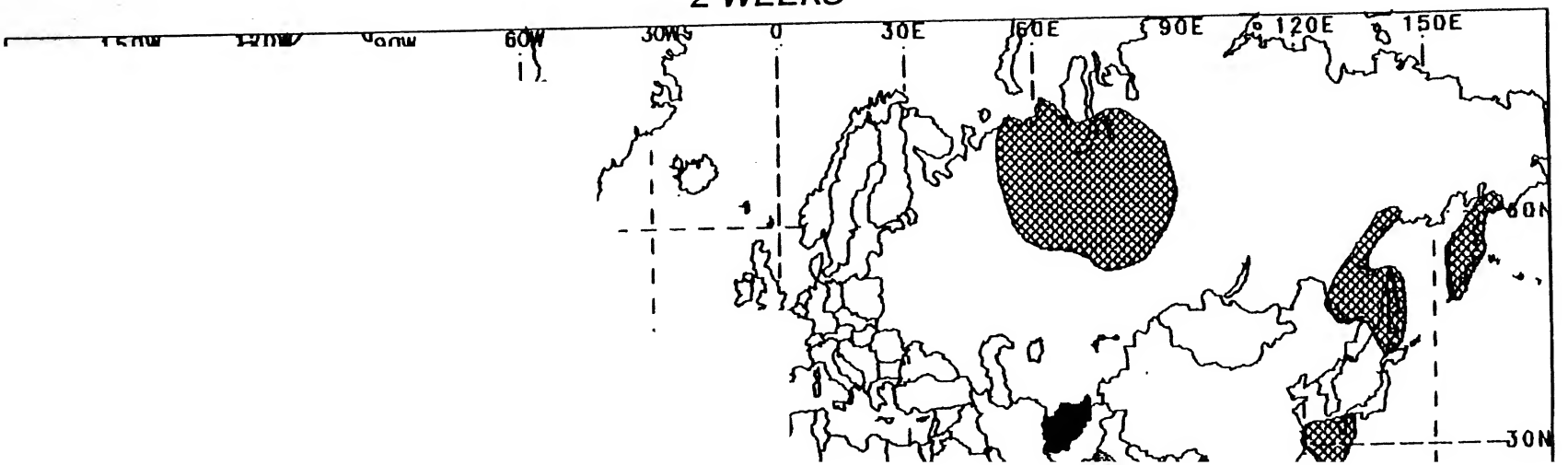


Hot weather generated large cooling usage in much of the Far West and across the southeastern quarter of the country (top). Since the beginning of the year, persistently mild weather has caused above normal cooling demand throughout the nation, except in portions of the Northeast, Great Lakes, Midwest, northern Great Plains, and northwestern Arizona, where most of the mild conditions occurred during the heating (winter) season (bottom).



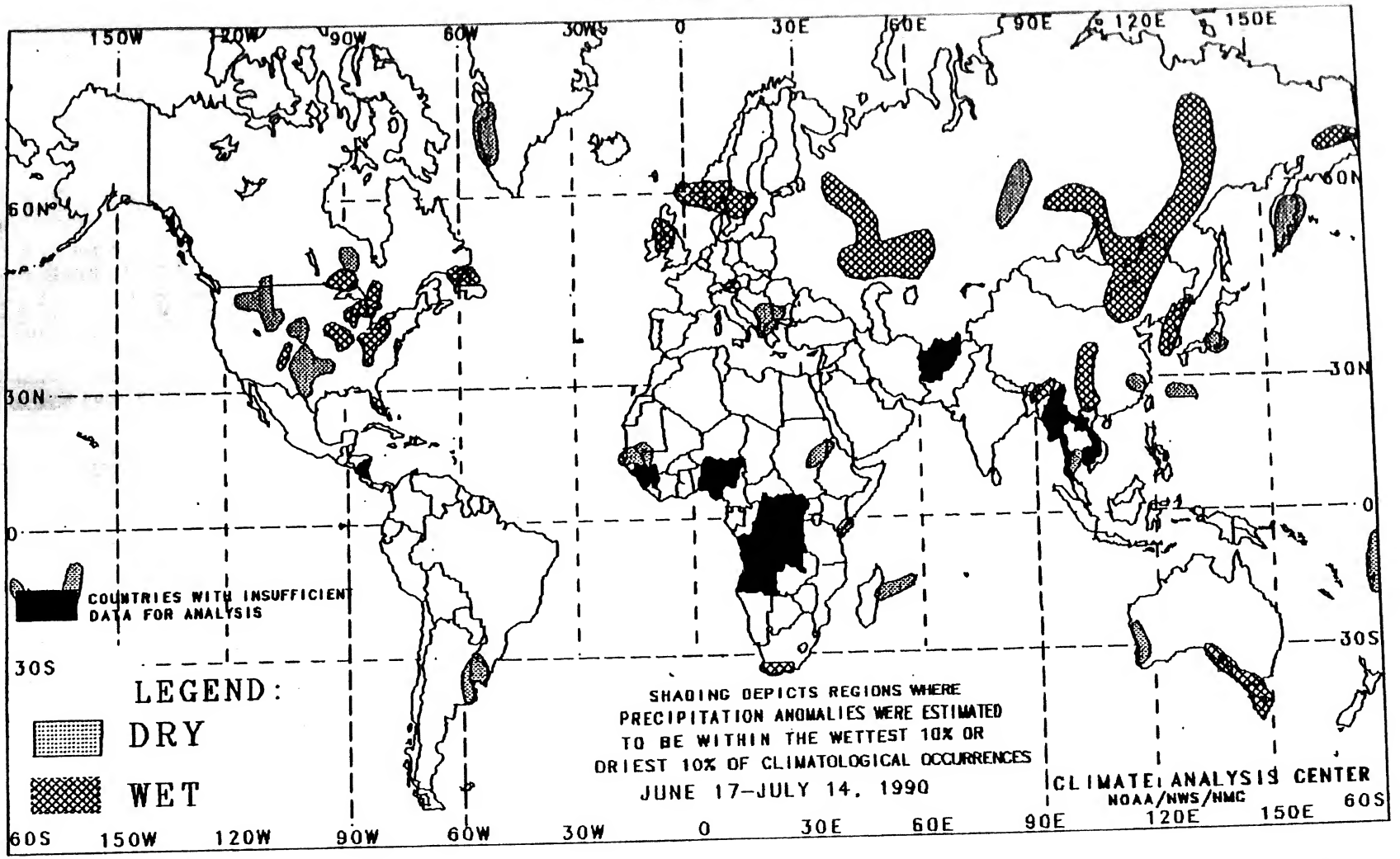
GLOBAL TEMPERATURE ANOMALIES

2 WEEKS



GLOBAL PRECIPITATION ANOMALIES

4 WEEKS



The anomalies on this chart are based on approximately 2500 observing stations for which at least 27 days of precipitation observations (including zero amounts) were received or estimated from synoptic reports. As a result of both missing observations and the use of estimates from synoptic reports (which are conservative), a dry bias in the total precipitation amount may exist for some stations used in this analysis. This in turn may have resulted in an overestimation of the extent of some dry anomalies.

In climatologically arid regions where normal precipitation for the four week period is less than 20 mm, dry anomalies are not depicted. Additionally, wet anomalies for such arid regions are not depicted unless the total four week precipitation exceeds 50 mm.

In some regions, insufficient data exist to determine the magnitude of anomalies. These regions are located in parts of tropical Africa, southwestern Asia, interior equatorial South America, and along the Arctic Coast. Either current data are too sparse or incomplete for analysis, or historical data are insufficient for determining percentiles, or both. No attempt has been made to estimate the magnitude of anomalies in such regions.

The chart shows general areas of four week precipitation anomalies. Caution must be used in relating it to local conditions, especially in mountainous regions.

SPECIAL CLIMATE SUMMARY

EL NIÑO SOUTHERN OSCILLATION (ENSO) DIAGNOSTIC ADVISORY 90/6

issued by

DIAGNOSTICS BRANCH
THE CLIMATE ANALYSIS CENTER
NATIONAL METEOROLOGICAL CENTER, NWS

July 11, 1990

Tropical Pacific oceanic and atmospheric indices indicate near normal conditions. Sea surface temperature (SST) anomalies were slightly positive in all three Nino index regions, but in each case the anomalies were less than 0.5°C. During June, a warm pool of water (SSTs greater than 30°C) was found along the equator near 160°E, where SST anomalies exceeded 1°C. The oceanic thermocline deepened in that region during June compared to the relatively shallow levels of the past few months.

Atmospheric convection, as indicated by the outgoing longwave radiation (OLR), and low–level easterlies were near normal in the central equatorial Pacific. However, low–level easterlies were slightly weaker than normal in both the eastern and western regions. After a swing to positive last month, the Southern Oscillation Index (SOI) dropped back to zero in June as both Tahiti and Darwin registered near normal sea level pressure.

During the last few months, atmospheric convection and low–level winds have been near normal in the tropical central Pacific, and the SOI has risen to near zero. Thus, the atmospheric indications of a developing warm episode that were present during early 1990 have faded away. However, sea surface temperatures have continued slightly warmer than normal, especially just north of the equator from 120°W to 140°W and along the equator near 160°E (Figure 1). Most ENSO prediction models presently indicate continued warming for the next two tr
equatorial Pacific between 120°W and 170°W, but with positive a
different from zero.

As mentioned in the #90/5 ENSO Advisory of June 11, 1990 (
#90/23 dated June 9, pages 9–12), the future course of events may well
abnormally warm water in the western Pacific, which in June exceede
late 1987 (Figure 2). A particularly critical time period will be the trans
weakens over Southeast Asia and shifts southward towards the equat
the warm pool evolves to a position near the date line, then enhance
normal easterlies would be favored in that region. The next Advi
September.

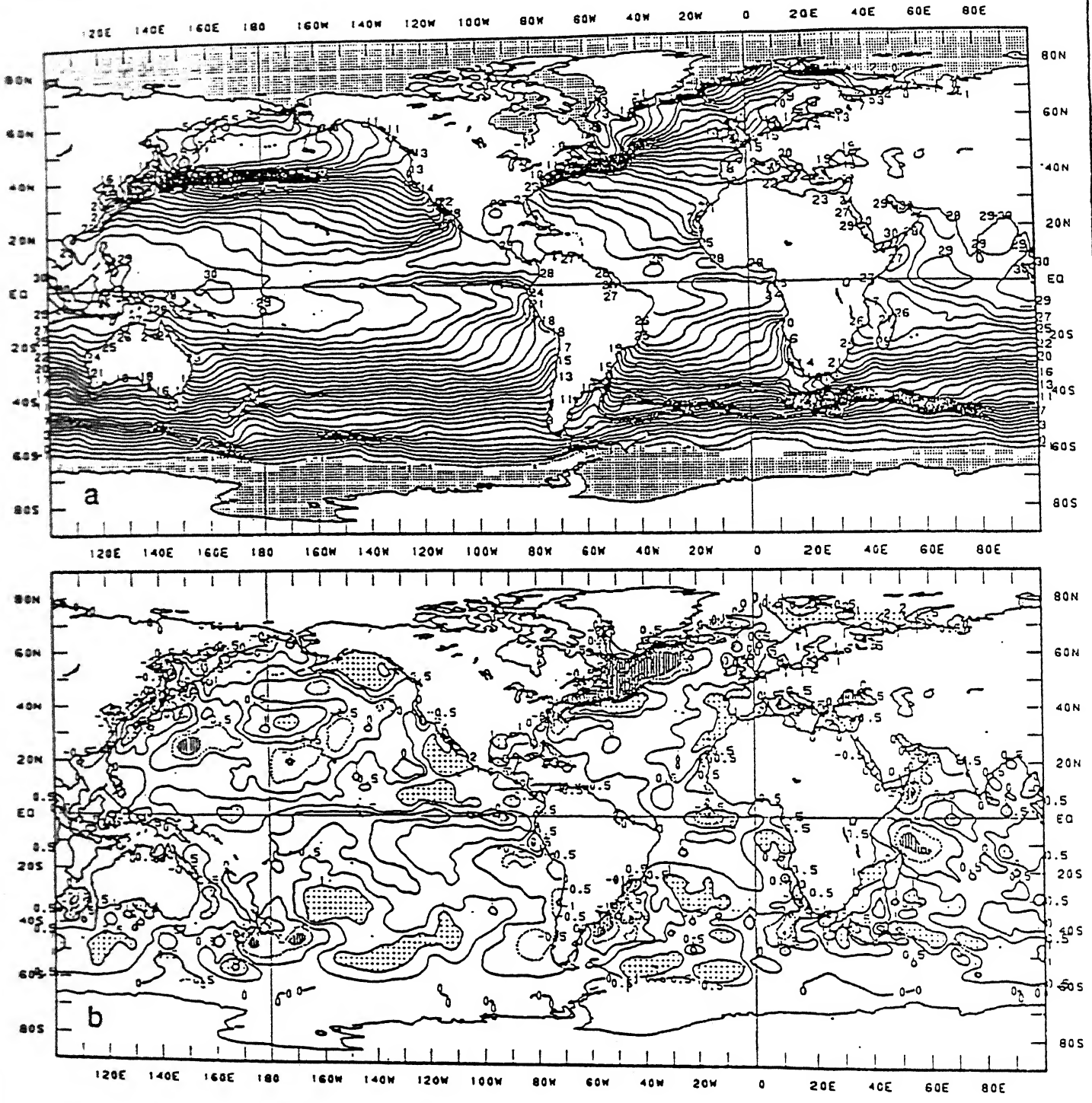


Figure 1. Blended sea surface temperature a) mean and b) anomalies for June 1990. The contour interval is 1°C and negative contours are dotted. Heavy contours are at 0°C and multiples of 5°C. The stippling in a) indicates sea ice cover. In b), anomalies less than -1°C are hatched and greater than 1°C are dotted. Additional anomaly contours of +0.5°C are shown. Anomalies in b) are computed as departures from the COADS/ICE climatology (Reynolds, 1988, J. Climate 1, 75-86).

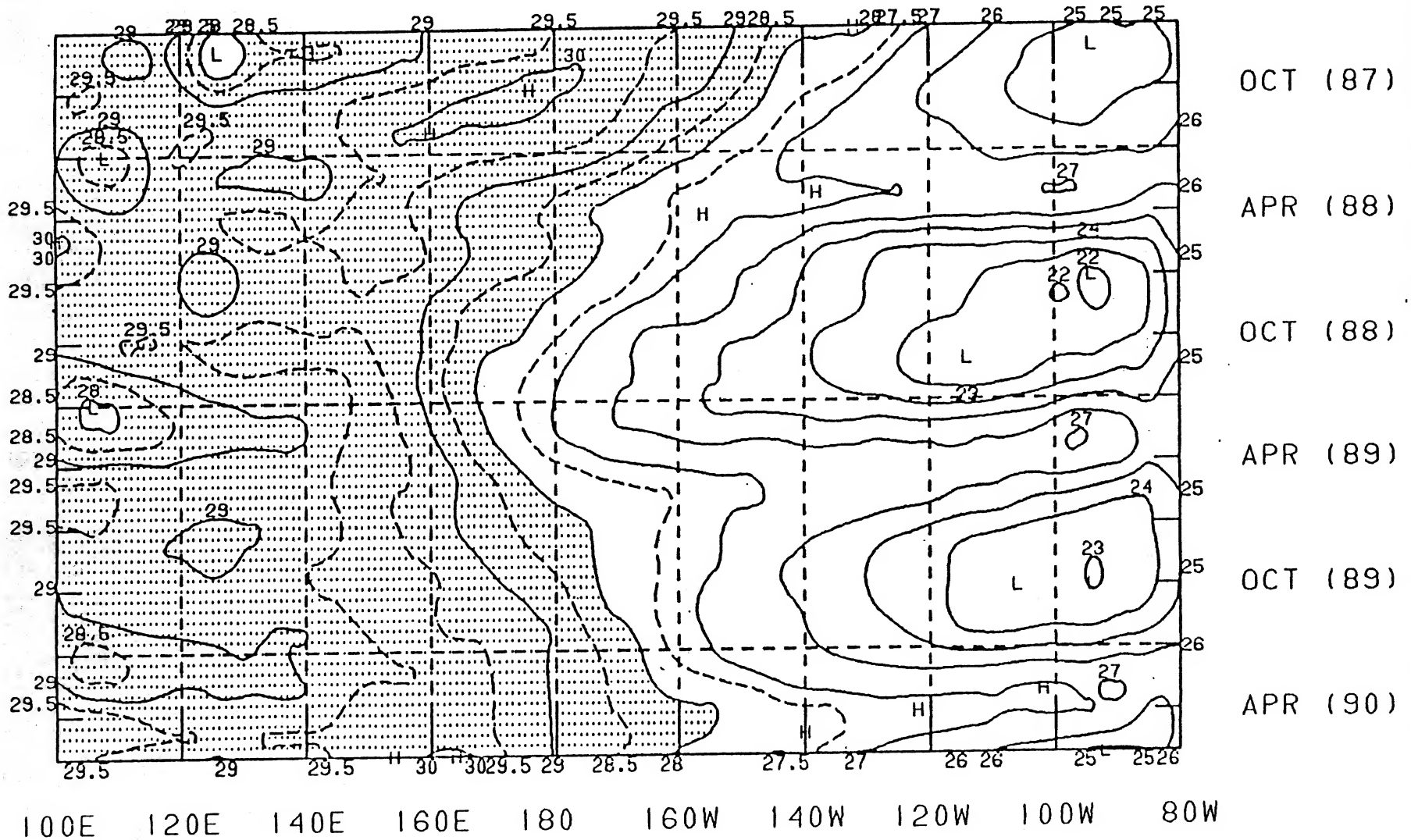


Figure 2. Time-longitude section of monthly mean sea surface temperature (SST) for 5°N-5°S. Contour interval is 1°C with intermediate contours drawn for SST values greater than 27°C. Values greater than 28°C are shaded.

SPECIAL CLIMATE SUMMARY

ANALYSIS AND INFORMATION BRANCH
CLIMATE ANALYSIS CENTER, NMC
NATIONAL WEATHER SERVICE, NOAA

UPDATE ON THE 1990 INDIAN MONSOON SEASON

Similar to the African Sahel rainy season, the Indian monsoon normally occurs during June–September, although significant rain may fall during the late spring and early fall months (e.g. April, May, October), as was the case this Spring. The monsoon usually progresses northwestward from the Bay of Bengal and southern Bangladesh at the start of June and reaches its westernmost position (central Pakistan) by mid–July (Figure 1). By the start of September, however, the monsoon normally withdrawals southeastward from Pakistan and retreats to extreme southern India by the end of October.

During the 5–month period of May–September, more than 90% of the ANNUAL rainfall normally occurs over much of western and north–central India. The remainder of India (except the extreme southern and northern portions), Bangladesh, and eastern Pakistan usually receives more than three–fourths of its usual yearly rainfall during this period (Figure 2). As depicted in Figure 3, the largest totals (>2000 mm) are normally measured along the southwestern Indian and Bangladesh Coasts and in northeastern India (Assam state).

After several years of weak monsoonal rains, extreme drought, and famine during the early and mid–1980's, the past two seasons have brought near to above normal rainfall to much of the region. Unfortunately, the last two seasons, especially 1988, was marked by severe, widespread flooding that caused numerous loss of lives and extensive property and agricultural damage, particularly in Bangladesh and northern sections of India (see Weekly Climate Bulletin #89/39 dated September 30, 1989, pages 14–18).

Earlier this year, unseasonably heavy rains fell along the eastern Indian Coast during late February and March, which then shifted northeastward into Bangladesh and northeastern India by late March and early April. By mid to late April, a series of strong storms battered parts of Bangladesh, causing flash floods, numerous deaths, and extensive damage, according to press reports.

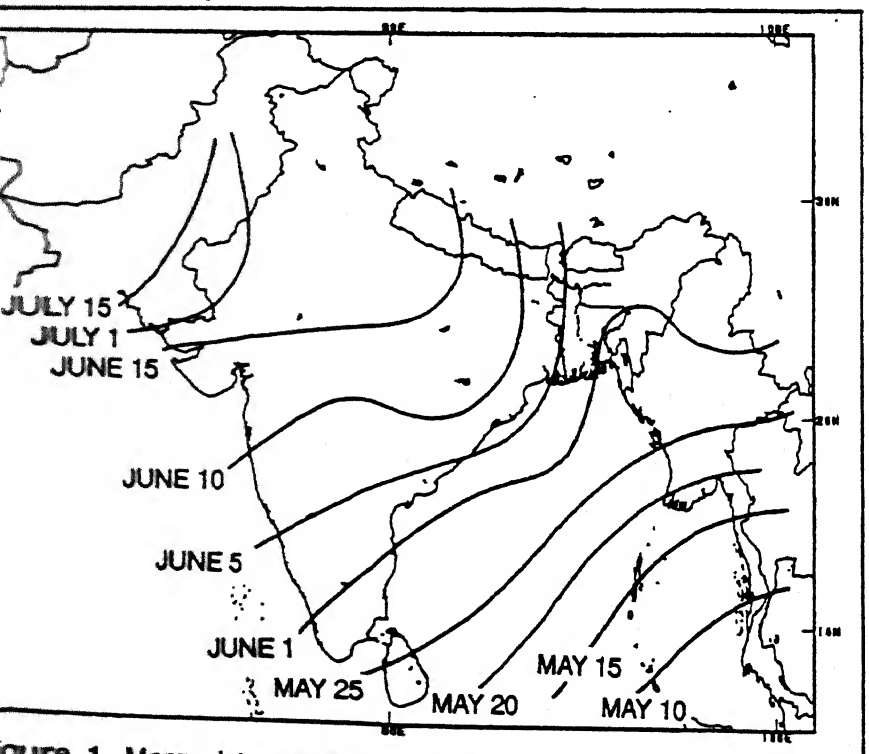


Figure 1. Mean dates of the southwest monsoon's northwestern advance across Bangladesh, India, and Pakistan from May 10 through July 15.

In early May, an intense cyclone, thought to be the most severe in over a decade in India, battered the southeastern Indian Coast, making landfall in the rich agricultural state of Andhra Pradesh (see Weekly Climate Bulletin #90/19 dated May 12). Even though advanced warnings and evacuations had saved untold lives, the death toll by late May had surpassed 1,000.

During June, the monsoon progressed northwestward slightly ahead of schedule, dumping ample rains on southwestern and eastern India and Bangladesh. Additional flooding occurred in northwestern Bangladesh as heavy rains in northeastern India swelled downstream rivers out of their banks. Towards mid–month, torrential downpours dumped over 560 mm of rain in a 24–hour period on parts of Bombay, India's largest city, with more than 400 mm occurring during one 6–hour period, according to the Indian Weather Service. Farther north, a brief heat wave, with highs above 40°C, claimed more than 50 lives in the northern Indian city of Jammu late in the month.

In July, heavy rains flooded parts of southeastern Bangladesh, affecting nearly two million people. Durin first week of July, heavy rains hit northern and western India, taking a toll of 140 lives and producing exten property and agricultural damage, according to the Press Trust of India (PTI). Conditions eased somewhat du the second week of July in western and northern India, but worsened in northeastern India as over 300 inundated sections of Assam state.

Since May 1, most of Bangladesh and eastern and northern India has recorded surplus rainfall (front co Although meteorological reports from Bangladesh are incomplete, supplemental information from satellite and press reports indicated a very wet season. May 1–July 14 precipitation totals, as expected, surpassed 1 mm along the normally wet southwestern Indian Coast and in northeastern India [and most likely soutl Bangladesh] (Figure 4). In contrast, areas with less than half the normal rainfall included parts of southern I in Tamil Nadu and Karnataka states and in sections of extreme western India and eastern Pakistan, although monsoon does not normally reach central Pakistan until mid–July.

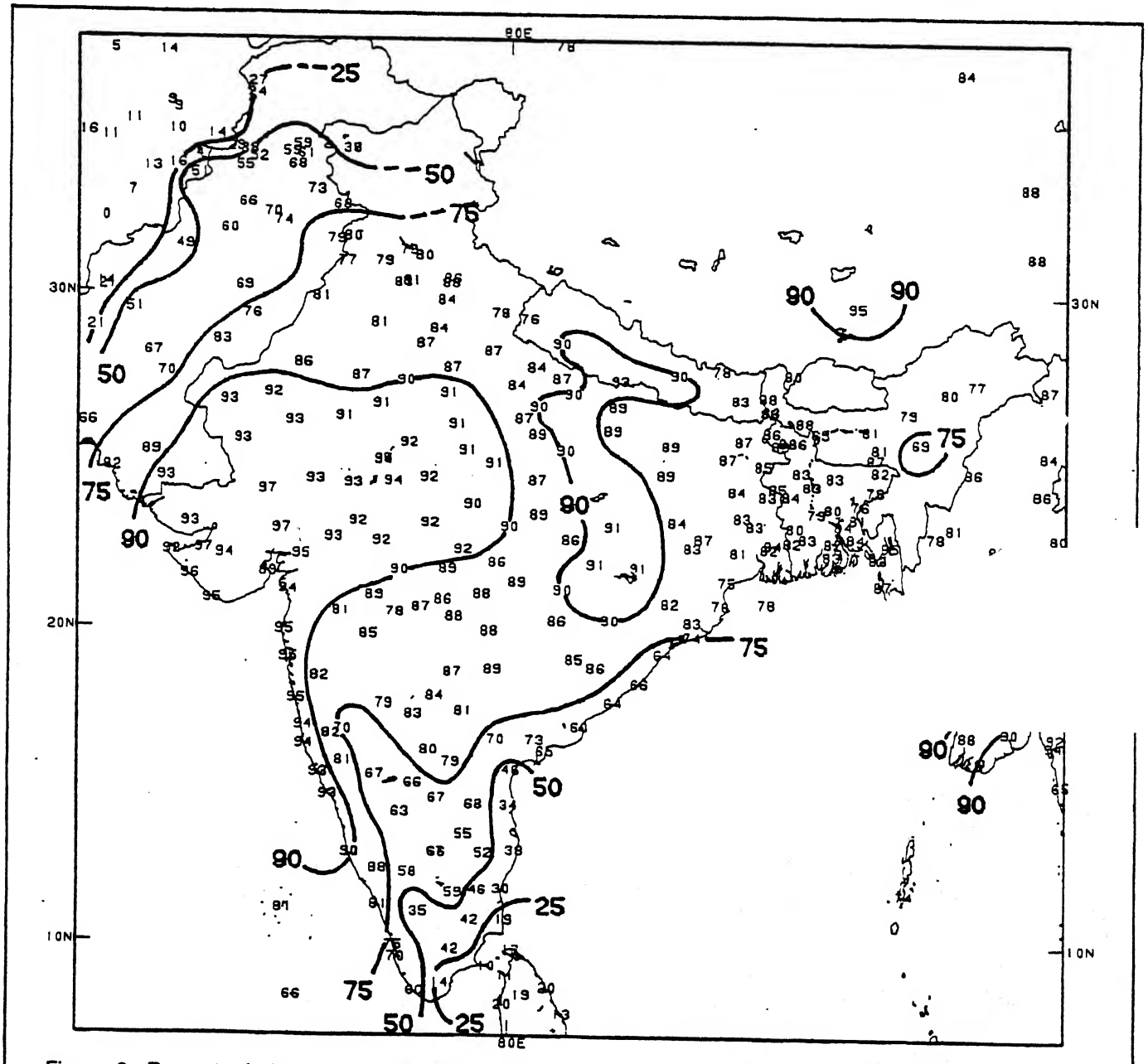


Figure 2. Percent of the normal ANNUAL precipitation that occurs during May-September (5 months). Isopleths are only drawn for 25, 50, 75, and 90%. If precipitation was evenly distributed during each month, then a 3-month period would have 25% (3/12) of the yearly precipitation, and a 6-month period would have 50% (6/12). During the 5-month period of May-September, over 90% of the yearly rainfall usually occurs across western and north-central India, with much of Bangladesh, eastern Pakistan, and most of the remainder of India normally receiving over three-fourths of its annual rainfall during this same period. As a result, this time of the year is critical for agriculture in much of the region.

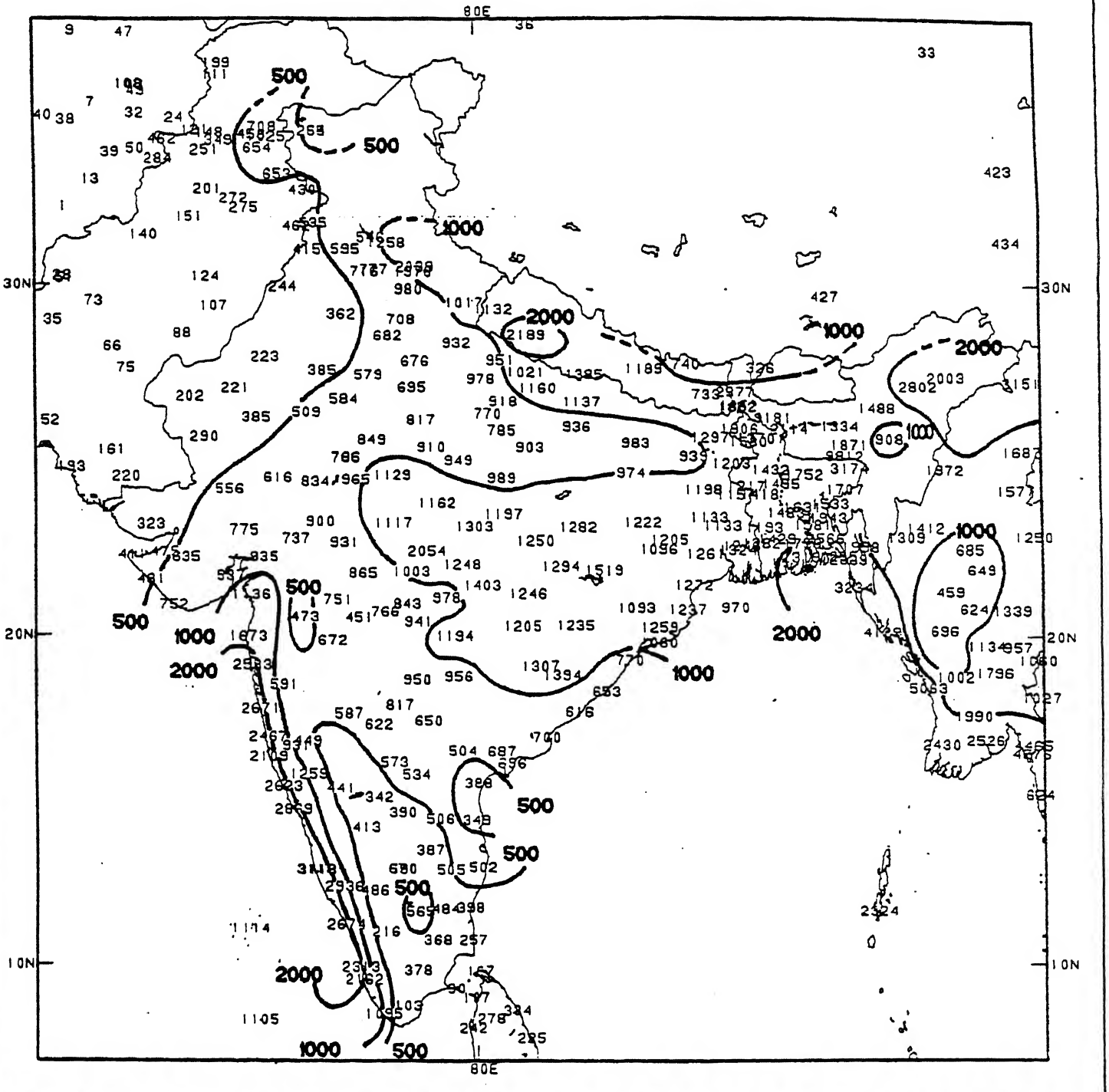


Figure 3. Total normal precipitation (mm) for May-September. Isohyets are only drawn for 500, 1000, and 2000 mm. The greatest amounts (>2000 mm) normally occur along India's southwestern and Bangladesh's southern coasts and in northeastern India's Assam state. During the summer months, precipitation generally increases from west to east and from south to north.

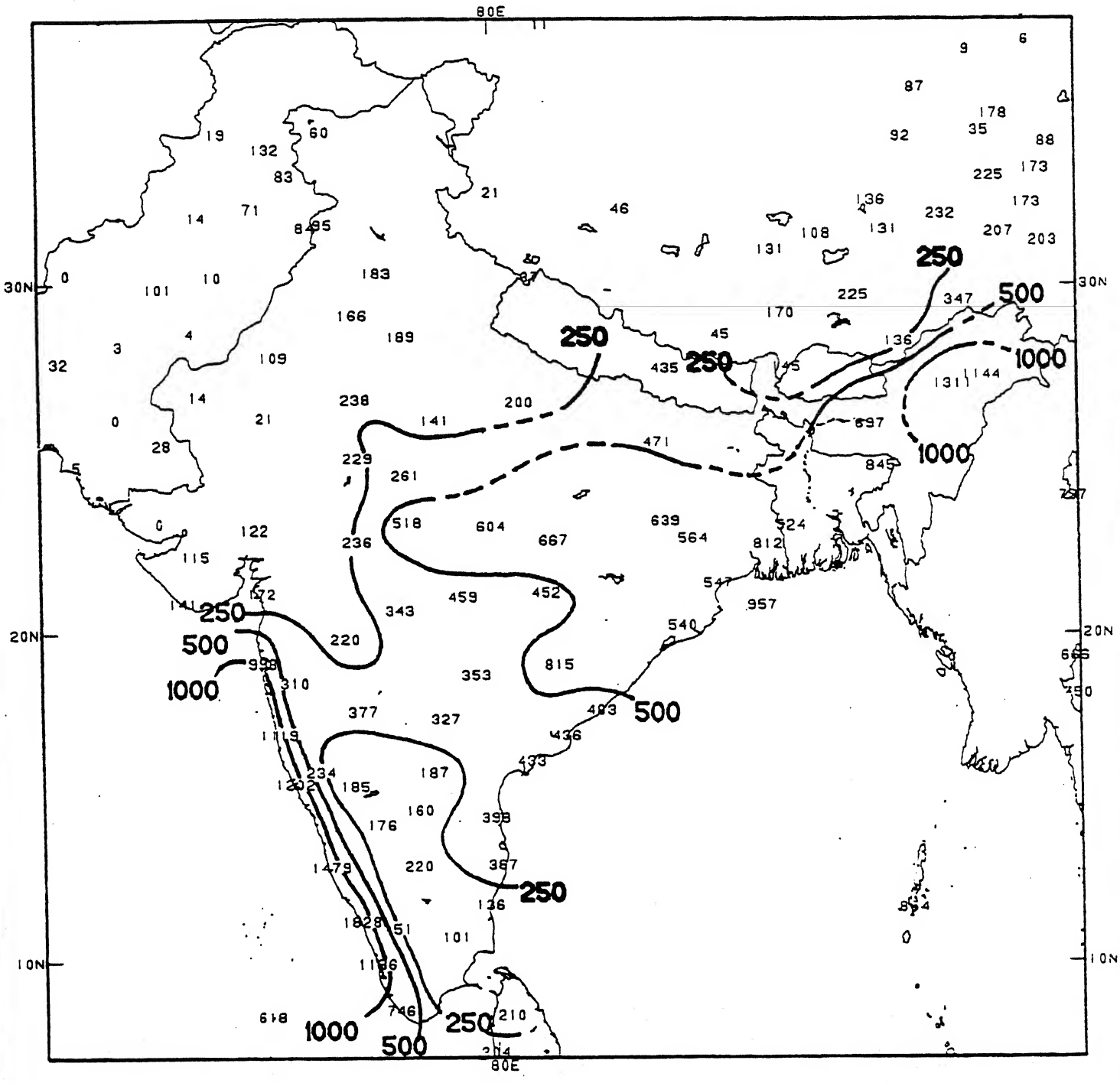


Figure 4. Total precipitation (mm) during May 1-July 14, 1990 (75 days). A station had to report 80% (60 days) or more of the days for inclusion. Isopleths are only drawn for 250, 500, and 1000 mm. Meteorological data in Bangladesh was incomplete, but supplemental information indicated near to much above normal seasonal rainfall. Generous rains have drenched much of eastern and northern India (and most likely Bangladesh) as the monsoon has generally progressed near or slightly ahead of schedule. Subnormal rainfall was limited to parts of southern and extreme western India and eastern Pakistan, where the monsoon has been either weak or slightly late.

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REVIEW OF THE 1990 AFRICAN SAHEL RAINY SEASON.

Rain typically falls in a very distinct pattern across the swath of Africa that lies north of the equator but south of the Sahara Desert. Locations close to the equator generally receive rainfall throughout the year, with some locations experiencing a weak maximum during the winter months. North of about 5°N latitude, however, a pronounced maximum occurs during the summer months (May – September), which becomes more pronounced near the Sahara (Figure 1). North of 10°N latitude, more than 90% of the annual precipitation is normally measured during the summer months. In addition, the rainy season shortens and total annual precipitation decreases as one continues northward until reaching the desert, where little or no rain is usually recorded. Coastal locations in Guinea and Sierra Leone normally measure 1500 mm – 2000 mm during the summer while the area from northern Senegal eastward through the central Sudan observes only one–fourth of that (Figure 2)

The precipitation is generally carried northward by the intertropical convergence zone (ITCZ), which typically reaches its northernmost location during August before retreating southward (Figure 3). The extent of this northward migration and the amount of convective activity that accompanies it determine how sub–Saharan Africa fares during a given rainy season.

As April 1990 came to an end, most locations south of about 8°Nlatitude (normally the northern extent of rainfall by May 1) had recorded slightly but not alarmingly below normal rainfall totals. Farther east, however, inundating rains, among the heaviest in recent history, deluged the Ethiopian highlands, generating widespread floods along several downstream rivers in Somalia. Numerous villages were isolated by the flooding, which destroyed more than 13,000 acres of crops and left 300 families homeless, according to press reports.

May commenced with a freakish rainstorm in southern Nigeria that destroyed several houses, trees, and electrical poles and claimed 20 lives. This downpour, however, did not prove to be an omen for the rest of May. Although amounts were at or above normal across Burkina Faso, Niger, and southern Mali, most areas recorded slightly below normal precipitation during May. Extremely dry weather developed across Senegal and the Gambia, where Kedougou, Senegal observed its third driest May in forty years. Fortunately, May precipitation has little bearing on crops in the western half of the Sahel, since little crop planting occurs before June. Farther east, where some crops are planted before June, adequate rains fell in southern Chad and the southwestern Sudan, but dry weather prevailed elsewhere. Portions of Northern Upper Nile, Blue Nile, and Kordofan provinces in the Sudan recorded well under half of the 20–year normal. Impacts on crop development, however, were largely dependent on crop stage since unusually heavy rains fell from February through April.

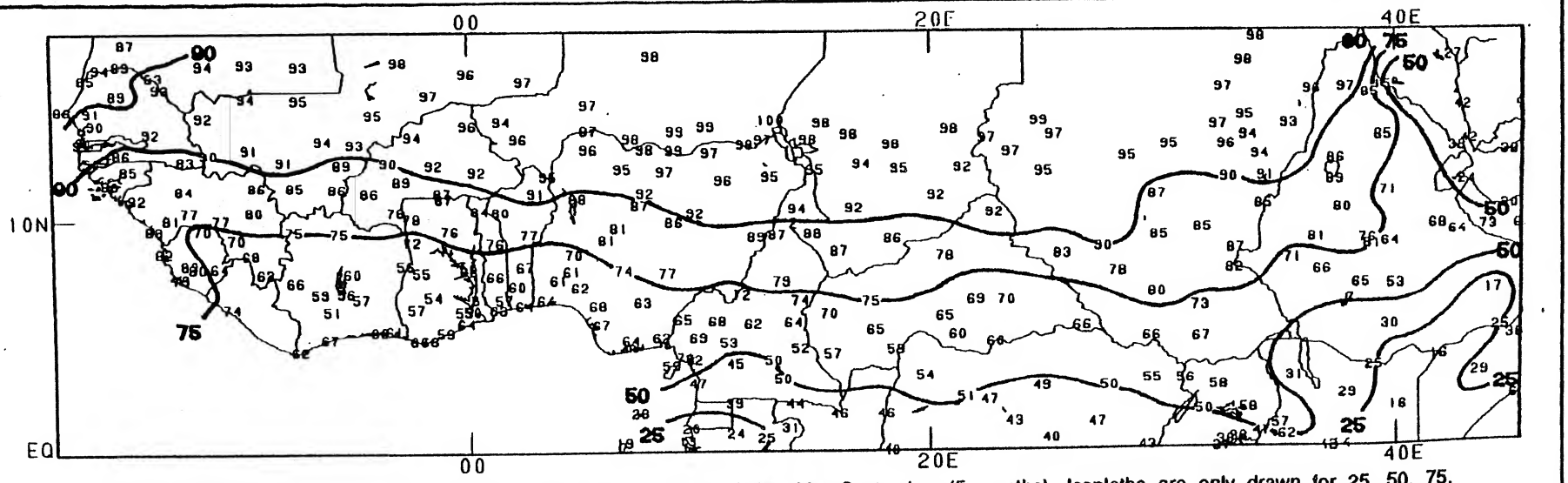

Figure 1. Percent of the annual precipitation that normally occurs during May-September (5 months). Isopleths are only drawn for 25, 50, 75, and 90%. If precipitation was evenly distributed during the year, then a 3-month period would have 25% (3/12) of the yearly precipitation, and a 6-month period would have 50% (6/12). In the Sahel, more than 90% of the annual rainfall falls during May-September approximately north of 10°N latitude and south of the Sahara Desert. Values gradually decrease southward, with precipitation evenly distributed throughout the year around the equator. In the Ethiopian highlands, however, there are other minor rainfall maximums during the remainder of the year.

Significant dryness (among the driest 10% of climatological occurrences) developed into a severe problem during June across much of the Sahel. Less than half the normal rainfall was again recorded in western Senegal as well as across most of Cote d'Ivoire, northern Ghana and southern Burkina Faso, central and southern parts of Benin and Togo, northeastern Nigeria and southeastern Niger, central Chad, central and southeastern Sudan, and much of extreme western, northern and northeastern Ethiopia. Abundant rainfall was again restricted to parts of Burkina Faso, Mali, and southwestern Chad, with moderate to heavy June rains helping to alleviate earlier dryness in eastern Senegal and west–central Ethiopia. By the end of June, most of northern Guinea, southeastern Senegal, Cote d'Ivoire, Southern Burkina Faso, and east–central Ethiopia had experienced four weeks of climatologically significant dryness.

Fortunately, rainfall increased in late June across most of the stressed regions, and this has continued through the first half of July. During July 1 – 10, above normal rainfall dampened most of Cote d'Ivoire Ghana, Benin, Togo, Nigeria, southern Niger, western Chad, the northern Central African Republic, and all but east–central portions of the Sudan. Dry weather, however, continued in other areas, and was especially severe across Senegal, southern Mali, east–central Chad, the eastern Sudan, and most of Ethiopia. The copious rains brought an end to short–term (four week) moisture deficits in most areas, except the parched Senegal, east–central Chad, and the east–central Sudan.

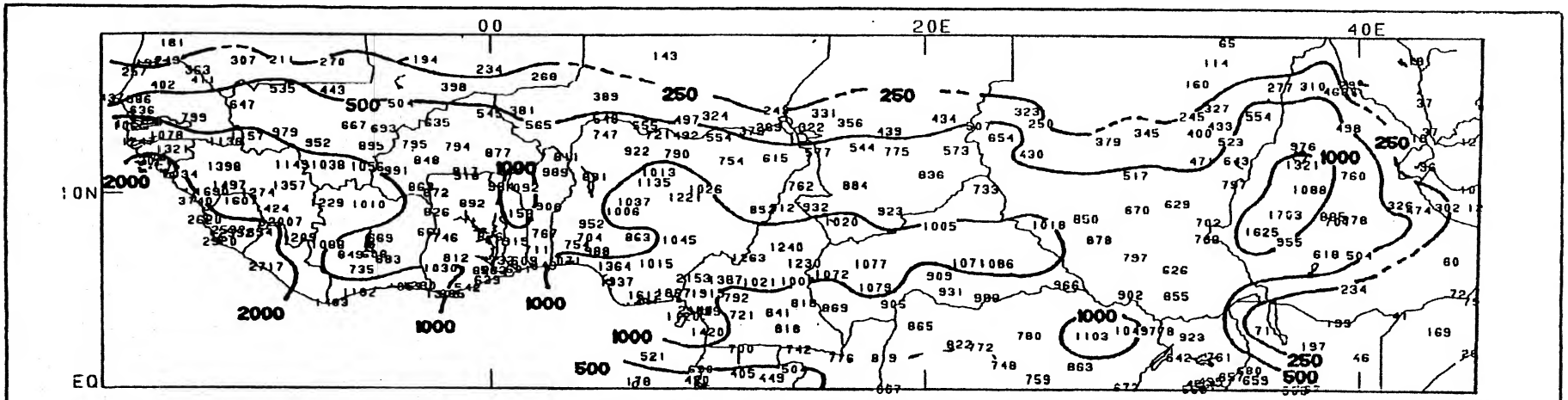

Figure 2. Total normal precipitation (mm) during May-September. Isohyets are only drawn for 250, 500, 1000, and 2000 mm. During the rainy season, the largest precipitation totals are along the coasts of Guinea, Sierra Leone, and Liberia, with additional large amounts (more than 1000 mm) across Nigeria, Cameroon, the Central African Republic, and the highlands of Ethiopia. Five-month rainfall totals rapidly decrease north of 15°N and are generally less than 100 mm north of 18°N (Sahara Desert).

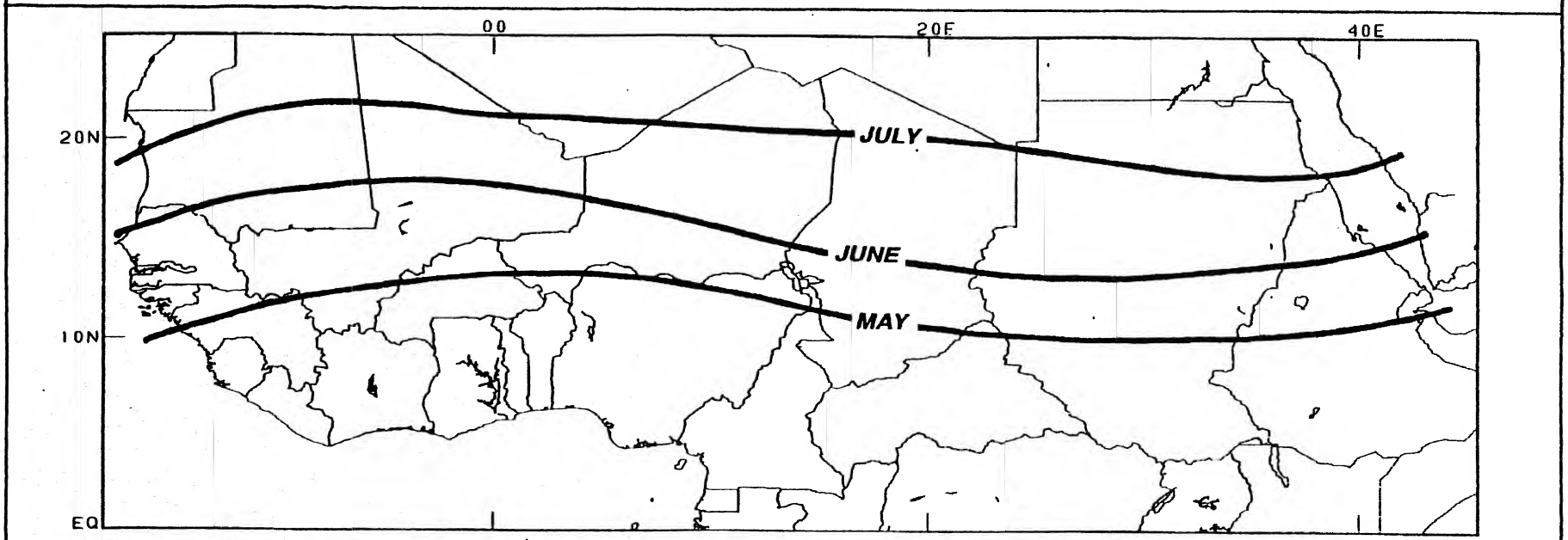

Figure 3. Approximate northern-most mean position of the Intertropical Convergence Zone (ITCZ) during May, June, and July (August and

from Nigeria, Cameroon, and the Central African Republic. Aforementioned references to these areas were based on short-term convective satellite estimates). Similar totals have also fallen across the Ethiopian highlands. Since most of the rain falls from scattered thundershowers, however, significant local variations may be noted. Above normal rainfall has been measured across western Cote d'Ivoire, southern Mali, much of Burkina Faso, and the southern tier of Niger, but most locations across the Sahel have recorded slightly below normal precipitation amounts (Figure 5). Unfortunately, severe dryness has developed in a few areas, notably northern Senegal, southern Mauritania, coastal locations across Cote d'Ivoire, Ghana, and Togo, as well as across central portions of Chad, the Sudan, and much of Ethiopia. These areas have observed less than half the normal precipitation since the beginning of the rainy season, and less than one-tenth of the normal rainfall has fallen on parts of the Sudan, Senegal, and Mauritania.

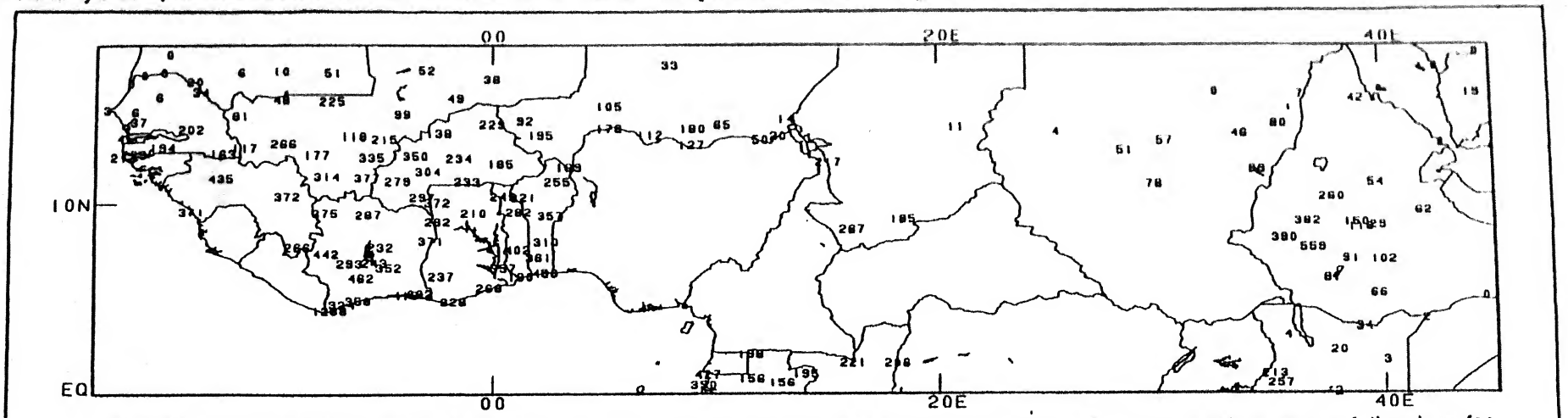

Figure 4. Total precipitation (mm) during May 1-July 14, 1990 (75 days). A station had to report 80% (60 days) or more of the days for inclusion. Countries with insufficient reports (no stations plotted) included: Nigeria, Cameroon, the Central African Republic, Zaire, Liberia, and Sierra Leone. Heavy rains (>300 mm) have been recorded in central and inferior western sections of the Sahel and in parts of the Ethiopian highlands, although some of these totals are below normal (see Figure 5). In contrast, little or no rain has fallen on parts of northern Senegal and southwestern Mauritania.

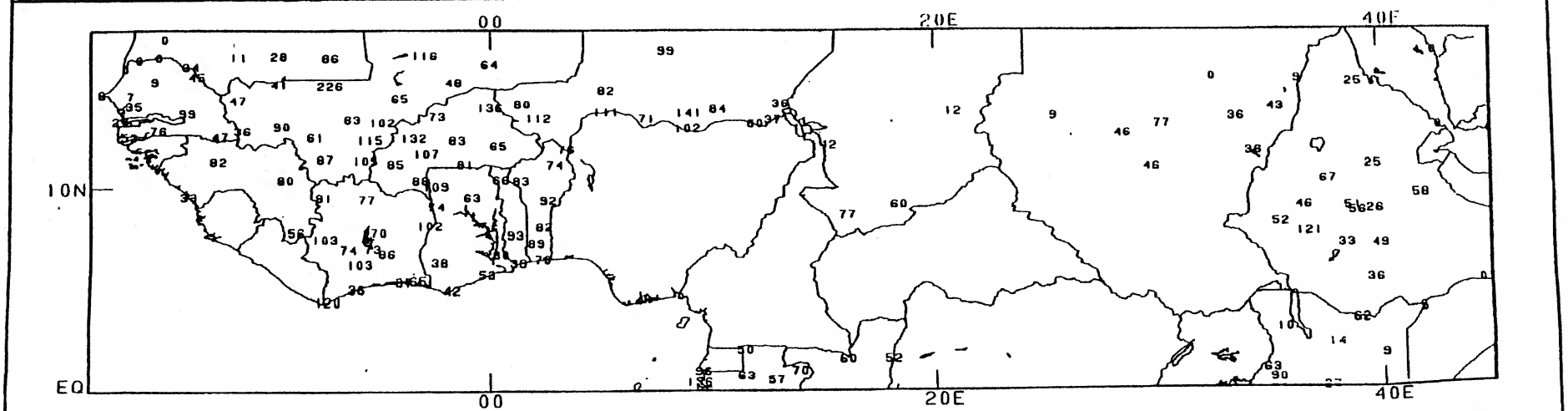

Figure 5. Percent of normal precipitation during May 1-July 14, 1990 (75 days). A station had to report 80% (60 days) or more of the days for inclusion. Countries with insufficient reports (no stations plotted) included: Nigeria, Cameroon, the Central African Republic, Zaire, Liberia, and Sierra Leone. Extreme dryness (<25% of normal rainfall) has afflicted western and northern Senegal, southwestern Mauritania, and parts of central Chad and Sudan while significantly below normal precipitation (<75% of normal) was observed across much of the eastern Sahel north of 10°N. In contrast, western Cote d'Ivoire, southern Mali, most of Burkina Faso, the southern tier of Niger, and most-likely northern Nigeria (from satellite data) recorded surplus seasonal rainfall, but the remainder of the region generally recorded slightly below normal precipitation.